Educational Inequality in the World, 1950-2010: Estimates from a New Data Set

Wail Benaabdelalai, Said Hanchane, Abdelhak Kamal

Abstract - This paper introduces a new quinquennial data set of educational inequality disaggregated by age group for 146 countries, from 1950 to 2010, by using the Gini index of education as a measure of the distribution of years of schooling. Based on recent estimates of average years of schooling from Barro and Lee (2010) our calculations take into consideration, for the first time, the changes over time in the duration of educational stages, in each country and for each age group. The downward trends in educational inequality observed during the last decades depend on age group, gender and development level.

JEL Classification: D63, I21, J24, O15

Keywords: Educational Inequality, Gini index of Education, Educational attainment, Age Group, Duration of educational stages

The authors would like to thank Lester Zeager for a careful reading and many helpful suggestions.

The data set of educational inequality measured by the Gini index of education of 146 countries from 1950 to 2010 is available at lead.univ-tln.fr

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I. Introduction

The analysis of inequality has been the centre of interest for scholars in the social sciences. However, most empirical work on inequality uses a unidimensional monetary perspective, which may not be sufficient for adequately characterizing this multidimensional phenomenon. The World Bank’s World Development Report of 2006, titled “Equity and Development,” moved for the first time beyond the question of income distribution, to emphasizing inequalities in key opportunity dimensions, such as health and education. While many questions about healthcare inequities have raised a lot of concerns for planners and policy makers, little attention was paid to educational inequality. During the last decades, however, researchers have realized the importance of putting more emphasis on educational inequalities. A recent but rapidly growing literature concerning education inequality has emerged. In fact, several data sets have been created to measure educational inequality (Castelló and Doménech, 2002; Thomas et al., 2001, 2003; Checchi, 2004; Araujo et al., 2004; Lim and Tang, 2008; Morrisson and Murtin, 2010; Meschi and Scervini, 2010; Castelló, 2010; Földvári and Van Leeuwen, 2011). The most popular and widely used is the one proposed by Thomas et al. (2001) who calculated a Gini index of education of the population aged 15 and over, based on school attainment data. Nevertheless, few studies have explored educational inequalities by age group. This paper introduces a new quinquennial data set of educational inequality for 146 countries, from 1950 to 2010, and is the first to present a Gini index of education by 5-year intervals and by sex for a broad panel. The Gini index of education is used as a measure of the distribution of years of schooling, with a more in-depth approach compared to existing data sets. After a brief discussion of the empirical literature on the issue - more specifically the existing datasets - we present the data we use in the estimation of the Gini index of education, describe the methodology and then illustrate some trends in the evolution of inequalities in the world.

II. Literature Review: A Brief Discussion

Research on inequalities in education is important both for political and empirical research. For public policy, it is a tool to assess the progress in educational development of a country. Important disparities in education can compromise the achievement of objectives related to the equality of opportunity. Furthermore, many recent empirical studies highlight the impact of the distributional dimension of human capital on economic growth. The Gini index of education is a measure of the relative inequality of the schooling distribution. It can be calculated using educational resources data, achievement, enrollment, or attainment data.

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1 Educational attainment is the most frequently used human capital proxy in the empirical literature. Indeed, average years of schooling gained popularity as adult literacy rates capture only the first stages of human capital accumulation and ignore knowledge and skills acquired beyond basic levels. Enrolment ratios ignore the cumulative benefits of completing additional years of schooling.
There have been many attempts to measure educational attainment. Barro and Lee (2010) made the most recent data set of educational attainment, which includes 146 countries from 1950 to 2010. The data are provided by sex and 5-year age intervals. They have improved the accuracy of estimation compared to estimates from earlier versions of the Barro-Lee Data Set (1993, 1996, and 2001) - by using consistent census data, disaggregated by age group, along with new estimates of mortality rates and completion rates by age and education level. Since Cohen and Soto (2007) and Barro and Lee (2010) are the most commonly used and most accurate data sets, Table n° 1 is used to present a comparison of both data sets using different criteria. In fact, data sources on educational attainments of Cohen and Soto (2007) are the OECD database and censuses published by UNESCO. Barro and Lee (2001, 2010) argued that there is a significant difference between the OECD data and UNESCO censuses which can cause inconsistency over time in case of a mix between the two sources. Indeed, OECD data comes mostly from household surveys which are based on samples of labor force and are obviously less robust than censuses. In addition, OECD data are available only for the 1990s, which can lead to underutilization of available information. Barro and Lee (2010) used only UNESCO censuses, with substantially more sources than Cohen and Soto (2007).

Table n°1: Comparison of Cohen and Soto’s (2007) and Barro and Lee’s (2010) Data Sets

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Data sources on educational attainment</td>
<td>OECD / UNESCO data</td>
<td>UNESCO data</td>
</tr>
<tr>
<td>Number of advanced countries (AC)</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>Number of UNESCO censuses for the AC</td>
<td>8</td>
<td>119</td>
</tr>
<tr>
<td>Number of total data sources for the AC</td>
<td>48</td>
<td>119</td>
</tr>
<tr>
<td>Number of developing countries (DC)</td>
<td>73</td>
<td>122</td>
</tr>
<tr>
<td>Number of UNESCO censuses for the DC</td>
<td>51</td>
<td>392</td>
</tr>
<tr>
<td>Number total data sources for the DC</td>
<td>70</td>
<td>392</td>
</tr>
<tr>
<td>Mortality rates</td>
<td>By age group</td>
<td>By age group and by educational level</td>
</tr>
<tr>
<td>Duration of educational stages</td>
<td>Homogenous</td>
<td>By age group and over time</td>
</tr>
<tr>
<td>Reliability ratio of series in 10-year differences*</td>
<td>0.88</td>
<td>1.00</td>
</tr>
<tr>
<td>Reliability ratio of series in levels</td>
<td>0.90</td>
<td>0.99</td>
</tr>
</tbody>
</table>

Source: The authors

*As used by Krueger and Lindahl (2001) in checking quality of schooling data, the reliability ratio gauges the fraction of the variability of a (unobserved) true variable in the total variability of the variable measured with error.

Indeed, Cohen and Soto’s estimation used only 51 UNESCO censuses among 70 data sources for 73 developing countries and 8 UNESCO censuses among 48 data sources for 22 advanced countries, compared to 392 UNESCO censuses for 122 developing countries and 119 for 24 advanced countries in Barro and Lee’s (2010) sample. In fact, Cohen and Soto (2007) considered the variation in mortality rates by age groups not by educational levels. They

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2 In addition to OECD and UNESCO data sources, Cohen and Soto (2007) also used data on educational attainment from Singapore and Bangladesh’s statistical offices websites.
have used homogenous duration of schooling stages rather than variations by age groups and over time utilized by Barro and Lee’s (2010) estimation. As Barro and Lee (2010) demonstrated, the reliability ratio for their estimation is greater than the one of Cohen and Soto (2007), in levels and in 10-year differences, in years of schooling for the population aged 15 years and older. Specifically, while the new Barro-Lee data set has reliability ratios of 0.99 for levels and 1.00 for differences, the reliability ratios of Cohen-Soto (2007) are 0.90 for levels and 0.88 for differences.

Thomas et al. (2001, 2003) were among the first to propose a new data set of the Gini index of education, based on school attainment data with the focus on the data set itself. However, several other data sets have been produced in some papers to estimate a Gini index of education with a focus on explaining economic growth, income inequality or other dependent variables. Although the objectives of these kinds of papers are not the same, the data sets used are still analyzed here thoroughly for the sake of comparison with our data set.

### Table n°2: Overview of Data Sets on Inequality in Educational Attainments

<table>
<thead>
<tr>
<th>Authors</th>
<th>Number of countries</th>
<th>Data sources</th>
<th>Number of levels of education</th>
<th>Period</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Araujo et al. (2004)</td>
<td>124</td>
<td>Household surveys</td>
<td>-</td>
<td>~ 2000</td>
<td>ACE</td>
</tr>
<tr>
<td>Meschi and Scervini (2010)</td>
<td>31</td>
<td>International surveys*</td>
<td>-</td>
<td>-</td>
<td>25+</td>
</tr>
</tbody>
</table>

Source: The authors


*The European Social Survey, the European Union Statistics on Income and Living Conditions, the International Adult Literacy Survey, and the International Social Survey Programme.

Moreover, few data sets have explored educational inequalities by age group. Our approach can significantly improve the measurement of inequality in education compared to the existing data sets by producing more realistic and reliable estimates of the Gini index of education, especially when

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3 For a chronological overview of existing data sets of inequality in educational attainments see Table n° 2.

4 The Socio-Economic Database for Latin America and the Caribbean (CEDLAS and The World Bank: SEDLAC (2011)) presents information on Gini coefficient for the distribution of years of education by age group. However, using household surveys data, it concerns only countries of Latin America and the Caribbean for discontinuous periods.
it comes to longitudinal and international comparisons. The data set suggested in this paper gives further insight on educational inequality for many reasons:

- First, as the quality of the estimation of educational attainment levels contributes to the accuracy of the estimation of the Gini index, we use Barro and Lee’s (2010) data set, whose estimation is more accurate and which has specific advantages compared to other data sets. Note that most of previous data sets of educational inequality were based either on Barro and Lee’s (1996, and 2001) or Cohen and Soto’s (2007) data sets discussed above.

- Second, the data set is constructed with seven levels of education. All data sets constructed using only four levels of education present a real limitation. Indeed, the Checchi (2004), Castelló and Doménech (2002), Földvári and Van Leeuwen (2011), and Castelló’s (2010) studies have used only four levels of education in their Gini coefficient calculations. These works cannot include the variation within a school stage because they do not differentiate between those who actually completed a level of education and those who did not.

- Third, as we exploit educational attainment data disaggregated by age, we take into account in our calculations the variation of the duration of schooling stages. Indeed, all previous data sets on the Gini index of education included neither the variation of duration of educational stages over time, nor the heterogeneity of age group’s duration system; in a given country, different generation groups have different schooling stages duration for each education stage. In fact, we take into account the heterogeneity of age group duration system over time and educational pathways of different cohorts within a population. Our duration of educational stages data used in the calculation of the Gini index makes no restriction on our data set of inequality in educational attainment, contrary to the duration of schooling stages by Thomas et al (2001, 2003) and Lim and Tang (2008). Thomas et al (2001, 2003) have used Psacharopoulos and Arriagada’s (1986) data of Duration of School Stages which are fixed in time and present only the duration of a broad secondary phase rather than the lower and upper secondary phases. In fact, the authors have used an approach which does not seem to be compatible with the data they used. Indeed, they hypothesized that the duration of schooling in the lower secondary stage corresponds to the half of the duration of a broad secondary phase. Furthermore, Lim and Tang’s (2008) duration of school stages are drawn from the UNESCO Institute for Statistics Database which restricts their data set to only 99 countries.

- Finally, our data set is the first to provide an education Gini index by 5-year age intervals and by sex for a broad 146 countries and also for

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5 No formal education, incomplete primary, complete primary, lower secondary, upper secondary, incomplete tertiary and complete tertiary.

6 Three fundamental educational stages are considered: Primary, Secondary and Tertiary.

7 Data on duration of educational stages can be obtained from the authors upon request.
aggregated groups of countries or age intervals, considering the variation and the heterogeneity within these aggregated groups.

III. Methodology: Estimation of the Gini index of education

The Gini coefficient is widely used to measure inequality in the distribution of income (Lambert, 2001). Analogously, Thomas and al. (2001) developed a Gini coefficient applied to education based on school attainment. Both indicators - income Gini and education Gini - are equal to one half of the mean difference between all pairs of observations, divided by mean. One difference between them is that educational attainment is a discrete variable, while income is generally considered as a continuous variable.

Our data set is about inequality in educational attainments measured by the Gini index of educational attainments. We adapted the formula of Thomas et al., 2001 to calculate a quinquennial Gini index of education of 146 countries by 5-year intervals and by sex and constructed a structural formula of the Gini index of education for aggregated groups which employs all the abundance of disaggregated data (for a broad age group {15+, 25+, [15, 65], [15, 24],[25, 34]…} and for groups of countries {The world, Advanced Countries, Developing Countries, Middle East and North Africa, Sub-Saharan Africa, Latin America and the Caribbean, East Asia and the Pacific, South Asia, and Europe and Central Asia}).

Starting from the formula of the income Gini index of the discrete case of Lambert (2001) and assuming there are "n" distinct income groups, and that within each income group "i" there are a number of individuals earning that income level, we can reconcile this Gini formula with the formula of Thomas et al. (2001):

\[
Gini = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} |y_{i} - y_{j}|}{2N^2 \mu}
\]

\[
= \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} \left( \frac{1}{N^2} \sum_{k=1}^{n} \sum_{l=1}^{n} |y_{ik} - y_{ij}| \right)}{2\mu}
\]

\[
= \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} \left( \frac{n_i}{N} \left( \frac{n_j}{N} \right) |y_{i} - y_{j}| \right)}{2\mu}
\]

\[
= \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} p_i |y_{i} - y_{j}| p_j}{2\mu}
\]

\[
= \frac{1}{\mu} \sum_{i=1}^{n} \sum_{j=1}^{n} p_i |y_{i} - y_{j}| p_j
\]

The developing group is further broken down into six regions: Middle East/North Africa (18 countries), Sub-Saharan Africa (33), Latin America/Caribbean (25), East Asia/Pacific (19), South Asia (7), and Europe and Central Asia (20).

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8 The developing group is further broken down into six regions: Middle East/North Africa (18 countries), Sub-Saharan Africa (33), Latin America/Caribbean (25), East Asia/Pacific (19), South Asia (7), and Europe and Central Asia (20).
\[ Gini = \frac{1}{\mu} \sum_{i=1}^{n} \sum_{j=1}^{i-1} p_i |y_i - y_j| p_j \] (1)

In order to reflect the population size and to standardize the following formulas, we can also rewrite the formula of the Gini index of education as:

\[ Gini = \frac{1}{\mu} \sum_{i=1}^{n} \sum_{j=1}^{i-1} p_i |y_i - y_j| p_j \]
\[ = \frac{\sum_{i=1}^{n} \sum_{j=1}^{i-1} \left( \frac{n_j}{N} \right) |y_i - y_j| \left( \frac{n_j}{N} \right) }{2\mu} \]
\[ = \frac{\sum_{i=1}^{n} \sum_{j=1}^{i-1} n_j |y_i - y_j| n_j }{2N\sum_{i=1}^{n} n_i y_i} \]
\[ Gini = \frac{\sum_{i=1}^{n} \sum_{j=1}^{i-1} n_j |y_i - y_j| n_j }{2N\sum_{i=1}^{n} n_i y_i} \] (2)

Note that the value of Gini is sensitive to population size \( N \) if the population size is too small. The sensitivity is reflected by a factor of \( \frac{N}{N-1} \). The education Gini formula for a small population is shown in Eq.(3).

\[ Gini_{small\ population} = \left( \frac{N}{N-1} \right) \left[ \frac{\sum_{i=1}^{n} \sum_{j=1}^{i-1} n_j |y_i - y_j| n_j }{2N\sum_{i=1}^{n} n_i y_i} \right] = \frac{\sum_{i=1}^{n} \sum_{j=1}^{i-1} n_j |y_i - y_j| n_j }{2(N-1)\sum_{i=1}^{n} n_i y_i} \] (3)

For all countries, regardless of age group, the population size is quite large, so that the difference between the value of Gini coefficient in Eq.(2) and Eq.(3) is very small.

**III.1. Gini index of education by age group**

\[ Gini_{c,i}^a = \frac{\sum_{i=1}^{n} \sum_{j=1}^{i} n_{c,i,j}^a |y_{c,i,j}^a - y_{c,j,i}^a| n_{c,i,j}^a }{2 N_{c,i}^a \sum_{i=1}^{n} n_{c,i,j}^a y_{c,i,j}^a} \] (4)
Where:

- \( Gini_{c,t}^a \): the Gini index of education of age group "a" for the country "c" at the time "t".
- Age group "a" corresponds to the following: \( a=1 \) to 15–19 age group, \( a=2 \) to 20–24 age group, ..., and \( a=13 \) to 75 and above.
- \( n \) corresponds to the number of educational levels which is equal in our study to 7.
- \( i \) and \( j \) are educational levels: \( i=1 \) for no formal education, \( i=2 \) for incomplete primary, \( i=3 \) for complete primary, \( i=4 \) for incomplete secondary, \( i=5 \) for complete secondary, \( i=6 \) for incomplete tertiary, and \( i=7 \) for complete tertiary.
- \( n_{c,i,t}^a \) represents the size of the population at the time "t", in the age group "a" and for the country "c" having attained the educational level "i".
- \( N_{c,t}^G \) represents the size of the population at the time "t", in the age group "a" and for the country "c". \( (N_{c,t}^G = \sum_{i=1}^n n_{c,i,t}^a ) \)
- \( y_{c,i,t}^a \): The number of years of schooling accumulated by group "a" in the country "c" to attain the educational level "i" at time "t".

IV.2. Gini index of education of aggregated group using disaggregated data by age

Instead of calculating the weighted average Gini index for world region or country group, we construct a structural formula which allows us to better harness the wealth of disaggregated data in order to calculate a Gini index of education of an aggregated group (group of age interval or group of countries = region) taking into consideration changes over time in the duration of educational stages in each country and for each age group.

\( a) \) Gini index of a broad age group

\[
Gini_{c,t}^G = \frac{\sum \sum n_{c,i,t}^a y_{c,i,t}^a - \sum \sum n_{c,j,t}^a y_{c,j,t}^a}{2 \sum \sum n_{c,i,t}^a y_{c,i,t}^a} \tag{5}
\]

Where:

- \( Gini_{c,t}^G \): the Gini index of education of the broad age group "G" for the country "c" at the time "t".

\( y_{c,j,t}^a \) is not explicitly available in Barro and Lee’s (2010) data set. We calculated \( y_{c,j,t}^a \) by merging the two Barro and Lee’s (2010) data sets corresponding to the total population and female [MF & F](see IV.3).

\( 15+, 25+, [15, 65], [15, 24],[25, 34]… \)
− Age group "a", "a’" corresponds to the following: a = 1 (a’ = 1) to 15–19 age group, a = 2 (a’ = 2) to 20–24 age group, ..., and a = 13 (a’ = 13) to 75 and above.
− \(N_{c,t}^G\) represents the size of the population at the time "t", in the broad age group "G" and for the country "c". \(N_{c,t}^G = \sum_{a \in G} \sum_{t=1}^{n} n_{c,i,t}^a = \sum_{a \in G} N_{c,t}^a\)

b) **Gini index of a broad group of countries**

\[
Gini_{R,t}^a = \frac{\sum_{c \in R} \sum_{a \in G} \sum_{t=1}^{n} n_{c,i,t}^a \left| y_{c,i,t}^a - y_{c,i,t}^a' \right| n_{c,i,t}^a}{2 N_{R,t}^a \sum_{c \in R} \sum_{t=1}^{n} n_{c,i,t}^a y_{c,i,t}^a} \tag{6}
\]

− Gini_{R,t}^a : the Gini index of education of age group "a" for the region "R" at the time "t".
− c (c’) represents a country in the region "R".

c) **Gini index of a broad group of countries (or region "R") and a broad age group**

\[
Gini_{R,t}^G = \frac{\sum_{c \in R} \sum_{a \in G} \sum_{t=1}^{n} n_{c,i,t}^a \left| y_{c,i,t}^a - y_{c,i,t}^a' \right| n_{c,i,t}^a}{2 N_{R,t}^G \sum_{c \in R} \sum_{t=1}^{n} n_{c,i,t}^a y_{c,i,t}^a} \tag{7}
\]

### III.2. Calculation of durations of schooling for each level of education \(y_{c,i,t}^a\)

The corresponding durations of schooling for each stage \(y_{c,i,t}^a\) are not explicitly available in Barro and Lee’s (2010) data set. The approach followed to find \(y_{c,i,t}^a\) is to merge the two Barro and Lee (2010) data sets of total and female populations and to use average years of schooling of each stage for both total and female populations.

The average years of schooling of the primary stage can be defined as the weighted average number of years of education received by individuals.

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\(^{12}\) For example G can be the population aged between [25-65], [15-24], or the 15 and over, 25 and over...

\(^{12}\) The world, Advanced Countries, Developing Countries, Middle East and North Africa, Sub-Saharan Africa, Latin America and the Caribbean, East Asia and the Pacific, South Asia, and Europe and Central Asia.
who completed and those who have not completed the primary stage of schooling. Indeed, as we mentioned before, we consider seven educational levels. So, in computing the average years of schooling of the primary stage, we take into account only individuals who have a primary education whether they have finished or not (i>1). In fact, the proportion of individuals who have not completed primary education would be equal to those who have reached level 2 (i = 2). However, for those who have completed it, we take into consideration the population with at least a primary school degree (i≥3).

\[ aystp_{c,j} = p_{c,2}^a \left[ y_{c,2,j}^a - y_{c,2}^a \right] + \sum_{j=5}^{7} p_{c,j}^a \left[ y_{c,j}^a - y_{c,3,j}^a \right] \]

(8)

Where \( p_{c,j}^a \): The fraction of group "a" in the country "c" having attained the educational level "i" at time "t".

The average years of schooling for secondary and higher stages can be obtained by following the same reasoning.

\[ ayss_{c,j} = p_{c,6}^a \left[ y_{c,6,j}^a - y_{c,6}^a \right] + \sum_{j=7}^{8} p_{c,j}^a \left[ y_{c,j}^a - y_{c,5,j}^a \right] \]

(9)

\[ ayst_{c,j} = p_{c,7}^a \left[ y_{c,7,j}^a - y_{c,7}^a \right] + p_{c,8}^a \left[ y_{c,8}^a - y_{c,6}^a \right] \]

(10)

We must calculate \( y_{c,j,t}^a \) for each country "c", for each age group "a" and for each time period "t". This results in finding seven unknowns. In order to perform our calculations, we must build a system of seven equations.

As the \( y_{c,j,t}^a \) are the same for males and females:

\[ y_{(mf),c,j,t}^a = y_{(m),c,j,t}^a = y_{(f),c,j,t}^a \]

(11)

We replicated the three equations for the average years of schooling of three stages \{(1), (2) and (3)\} for the total and female populations. In addition to this, the number of years of schooling accumulated by the illiterate population is equal to zero (\( \forall a \in [1,13]; y_{c,1,t}^a = 0 \)).

In total, we obtained for each age group of a given country at a given time a system of equations which corresponds to 24,674 systems of equations of seven equations and seven unknowns.\(^{13}\)

\(^{13}\) 146 countries for 13 age groups at 13 moments between 1950 and 2010 : \( 146 \times 13 \times 13 = 24674 \)
\[
\begin{align*}
asy_p^{(mf)}_{c,t} & = P_{(mf)}^{a} \left( y^a_{c,t} - y^a_{c,t} \right) + \left( \sum_{j=3}^{7} P_{(mf)}^{a} \right) \left( y^a_{c,t} - y^a_{c,t} \right), \\
asy_p^{(f)}_{c,t} & = P_{(f)}^{a} \left( y^a_{c,t} - y^a_{c,t} \right) + \left( \sum_{j=3}^{7} P_{(f)}^{a} \right) \left( y^a_{c,t} - y^a_{c,t} \right), \\
asy_s^{(mf)}_{c,t} & = P_{(mf)}^{a} \left( y^a_{c,t} - y^a_{c,t} \right) + \left( \sum_{j=3}^{7} P_{(mf)}^{a} \right) \left( y^a_{c,t} - y^a_{c,t} \right), \\
asy_s^{(f)}_{c,t} & = P_{(f)}^{a} \left( y^a_{c,t} - y^a_{c,t} \right) + \left( \sum_{j=3}^{7} P_{(f)}^{a} \right) \left( y^a_{c,t} - y^a_{c,t} \right), \\
asy_t^{(mf)}_{c,t} & = P_{(mf)}^{a} \left( y^a_{c,t} - y^a_{c,t} \right) + P_{(mf)}^{a} \left( y^a_{c,t} - y^a_{c,t} \right), \\
asy_t^{(f)}_{c,t} & = P_{(f)}^{a} \left( y^a_{c,t} - y^a_{c,t} \right) + P_{(f)}^{a} \left( y^a_{c,t} - y^a_{c,t} \right).
\end{align*}
\]

Where:

- \( asy_p^{(mf)}_{c,t} \): Average years of schooling of primary stage of the age group "a" of the country "c" in the total population at time "t".
- \( asy_s^{(mf)}_{c,t} \): Average years of schooling of secondary stage of the age group "a" of the country "c" in the total population at time "t".
- \( asy_t^{(mf)}_{c,t} \): Average years of schooling of tertiary stage of the age group "a" of the country "c" in the total population at time "t".
- \( asy_p^{(f)}_{c,t} \): Average years of schooling of primary stage of the age group "a" of the country "c" in the population of females at time "t".
- \( asy_s^{(f)}_{c,t} \): Average years of schooling of secondary stage of the age group "a" of the country "c" in the population of females at time "t".
- \( asy_t^{(f)}_{c,t} \): Average years of schooling of tertiary stage of the age group "a" of the country "c" in the population of females at time "t".
- \( P_{(mf)}^{a} \): The fraction of the age group "a" of the country "c" in the total population having attained the educational level "j" at time "t".
- \( P_{(f)}^{a} \): The fraction of the age group "a" of the country "c" in the population of females having attained the educational level "j" at time "t".

The system of equations can be solved using the substitution method:
It should be noted that when the denominator is equal to zero we can obtain the value of $y_{t}^{a}$ by the following equation ($y_{t-5}^{a} = y_{t}^{a+5}$), because it is the same cohort who went through the same educational system.

IV. Global Trends in Inequality in Educational Attainment

The data show that educational inequality has been declining for all regions and for all age groups during the last six decades (see Table 1). However, it did not occur in a uniform manner because it depends on age groups and development levels. The world Gini index of education decreased from 0.64 in 1950 to 0.34 in 2010 among the population aged 15 years and above. For advanced countries, the Gini index of education for the population aged 15 years and above decreased from 0.38 to 0.19, whereas for developing countries it declined from 0.73 to 0.36. Thus, among the population aged 15 years and above, the level of educational inequality for advanced countries, registered in 1950, is comparable to the level for developing countries in 2010. These results in a difference of 6 decades in terms of efforts allocated to reduce the educational inequality. The level of inequality was more pronounced in less developed countries in the 1950s, but they are greatly lowered over the period, although the 2010 level still remains higher than in developed countries.

Education inequality declined for all age groups, but the decline has been particularly strong for young people aged between 15 and 24 years old who have the most egalitarian distribution of education in 2010. The world Gini
index of education for this age group decreased from 0.56 to 0.24 between 1950 and 2010. In dynamics, however, the degree of inequality decreases with age. Note that the decline in inequality in developing countries has been the highest among the 15-24 years. They benefited from the quantitative progress related to the development of basic education in last century in these countries. These improvements in attainment among younger cohorts in every generation contribute to rising average years of schooling continually over time and to lower educational inequality. The gap between developed and developing countries has narrowed by 20 years over the young population aged 15-24 (see Figure 1).

The distribution of education as measured by Gini coefficients is very sensitive to the improvement of access to basic education and especially to the changes in the proportion of population with no schooling. This can be indicated by an education Lorenz curve (Figure 2). The shifting of a country’s education Lorenz curve closer to the egalitarian line indicates some improvement of education equality. An examination of the education Lorenz curves of developing and advanced countries shows that advanced countries have a more equitable distribution of education than developing countries, as they have a flatter Lorenz curve, virtually connected to the origin of the graph. In fact, they expanded basic education rapidly and eliminated illiteracy successfully in the early 1950s (the proportion of population aged 15 and older with no schooling declines from 9.2% in 1950 to 2.3% in 2010) and achieved higher educational attainment (5.7% of population aged 15 and above attained the tertiary stage in 1950, and this proportion rose to 25.6% in 2010). Despite progress in expanding basic education in developing countries, more than 17% of the population (aged 15 years old and over) did not receive any education in 2010 (61.2% in 1950) and only 9.2% have attained the tertiary stage in 2010.

Table 2 summarizes the educational inequality among males and females during the last six decades by development level and region. It shows a clear downward trend for both genders of the world population aged 15 and above. However, educational inequality depends on the development level and the geographical zone. In 2010, the gender gap - measured from calculating the absolute difference between Gini coefficients for males and females - is considerably small for advanced countries, while it remains persistent and substantial for developing countries. Education gender gap in Latin America and the Caribbean; Europe and Central Asia is gradually decreasing to reach low levels; while it is relatively big for East Asia and the Pacific. Although Middle East and North Africa; Sub-Saharan Africa and South Asia reported respectively a significantly bigger gap of 11%, 11% and 20%, these regions have achieved important progress in reducing the Gini coefficients for males and females. For example Middle East and North Africa begins at very high levels, but falls from 0.95 to 0.49 for females and from 0.89 to 0.38 for males.

In Figure 3, we plotted the Education Lorenz curves of developed and developing countries by age. A horizontal reading of the curves gives the
evolution of educational inequality in the same age through time. A vertical reading of the curves shows cross-section differences in educational inequality across age groups. A diagonal reading allows us to see the evolution of inequality within the same cohort through time. We can note for example that the level of inequality in the age group 15-24 has declined between 1950 and 2000, moving closer to that of developed countries. This reflects the advances in basic education for young people, especially during the last decades. As been said before; the degree of inequality is higher for upper age group. Indeed, the trend is downward over the period 1950-2010, while maintaining inter-generational differences.

Figure 4 shows that the Gini index of education declines with the increase of the average levels of education. Countries with a high average of years of schooling are likely to have weak levels of inequality. This trend is confirmed, as is the case in most of the empirical work, in our sample regardless of the region of the world. Thomas et al. (2001) find a strong negative association on cross-country data between Gini index of education and average years of schooling. This suggests that countries which spend more resources for education are also those where the distribution of enrolment between individuals is the most equitable. Moving any person out of illiteracy should improve the distribution of education and at the same time the level of educational attainment.

Our data show that the relation between inequality in education, measured by a standard deviation of schooling, and the level of schooling measured by the average years of schooling, follows a bell-shaped curve for the case of all selected regions (Figure 5). It means that during the development of education, the variance measured by standard deviation of schooling increases to reach a certain peak and then decreases. As in previous empirical work (Londoño, 1990; Ram, 1990; Thomas et al., 2001), the turning point is about seven years, after which, the dispersion between individuals in education declines. Note that the higher is the level of development, the higher is the turning point.

V. Conclusion

This work presents extensive research on the measurement of inequality in education. We propose a new data set on educational inequality by the estimation of a Gini index specific to education covering the period 1950-2010, the first attempt to present estimates by 5-year intervals and by gender for a broad panel. These estimates improve the measurement of inequality in education compared to the existing data sets by utilizing better estimation methodology, i.e. disaggregating by age group and paying more attention to the duration of schooling stages than in previous studies. The data reveal a decrease in inequality in the world for the whole period. We find contrasting trends, depending on the level of development and age group. Education inequality, more manifest in developing countries in the 1950s, is strongly lowered over the period. Still, in 2010, the level remains higher than in advanced countries. In terms of educational policy in these countries, more attention is needed to improving basic education and to reducing dropout.
rates in primary and secondary schools, which leads to greater school achievement in a quantitative sense.

However, our Gini index of education does not incorporate the quality aspect of education. So, in addition to attainment data, it is also important to analyze educational inequality with a more complete picture by utilizing cognitive achievement data. To deepen our understanding of inequality, it will be helpful to expand the current data set to include additional measures of human capital inequality, such as Theil, generalized entropy and Atkinson indices of education. Analyzing and exploring the determinants of educational inequality and its relationship to economic development is also an important issue for future research.
## VI. Tables and Figures

### Table 1. Education Gini by Development Level and Age Group, 1950, 1970, 1990, 2010

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Source: Author's calculations based on Barro-Lee Data (2010)

\[
G_{ij}^{c} = \frac{\sum_{a} \sum_{c} \sum_{i} \sum_{j} \left( n_{ij}^{c} \cdot y_{ij}^{a} \right) - \left( \sum_{a} \sum_{c} \sum_{i} n_{ij}^{c} \right) \left( \sum_{j} \sum_{i} y_{ij}^{a} \right)}{2 \left( \sum_{a} \sum_{c} \sum_{i} n_{ij}^{c} \right) \left( \sum_{j} \sum_{i} y_{ij}^{a} \right)}
\]

With

"a" Age group; "c" Country; "t" Time. Age group "a" corresponds for a=1 to 15–19 age group, a=2 to 20–24 age group, a=13 to 75 and above. n is the number of levels of education which is equal in our study to 7 levels. i and j are educational levels. j =1 for no formal education, j=2 for incomplete primary, j =3 for complete primary, j =4 for incomplete secondary, j =5 for complete secondary, j =6 for incomplete tertiary, j =7 for complete tertiary. \( n_{ij}^{c} \) represents the size of the population at the time "t" , in the age group "a" and for the country "c" having attained the educational level "i". \( y_{ij}^{a} \) is the number of years of schooling accumulated by group "a" to attain the educational level "j" at time "t".
Figure 1. Education Gini by Development Level and Age Group, 1950, 1970, 1990, 2010

![Education Gini by Development Level and Age Group](image1)

Figure 2. Education Lorenz Curve by Development Level (population aged 15 or older), 1950, 1980, 2010

![Education Lorenz Curve by Development Level](image2)
Table 2. Education Gini by Region and Gender (population aged 15 and over), 1950-2010

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By region

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Source: Author's calculations based on Barro-Lee Data (2010)

\[
Gini_{ij}^c = \frac{2 \sum_{i=1}^{n_i} \sum_{j=1}^{n_j} \sum_{k=1}^{n_k} x_{ijk}^c \left( y_{ijkl}^c - \bar{y}_{ijkl}^c \right)}{ \sum_{i=1}^{n_i} \sum_{j=1}^{n_j} \sum_{k=1}^{n_k} x_{ijk}^c \bar{y}_{ijkl}^c}
\]

With

- "a" Age group; "c" Country; "l" Time. Age group "a" corresponds for a=1 to 15–19 age group, a=2 to 20–24 age group, a=13 to 75 and above. n is the number of levels of education which is equal in our study to 7 levels. i and j are educational levels, j = 1 for no formal education, j=2 for incomplete primary, j =3 for complete primary, j =4 for incomplete secondary, j =5 for complete secondary, j =6 for incomplete tertiary, j =7 for complete tertiary. n_{ijk}^c represents the size of the population at the time "l", in the age group "a" and for the country "c" having attained the educational level "i": y_{ijkl}^c is the number of years of schooling accumulated by group "a" to attain the educational level "j" at time "l".
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<td>70-74</td>
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<tr>
<td>75 and over</td>
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</tbody>
</table>

| **Latin America and the Caribbean (25)** |      |      |      |      |
| 15-19        | 0.60 | 0.58 | 0.59 | 0.46 |
| 20-24        | 0.62 | 0.59 | 0.60 | 0.50 |
| 25-29        | 0.64 | 0.60 | 0.62 | 0.54 |
| 30-34        | 0.63 | 0.60 | 0.62 | 0.54 |
| 35-39        | 0.64 | 0.60 | 0.62 | 0.57 |
| 40-44        | 0.66 | 0.60 | 0.63 | 0.59 |
| 45-49        | 0.67 | 0.61 | 0.64 | 0.61 |
| 50-54        | 0.69 | 0.62 | 0.66 | 0.61 |
| 55-59        | 0.70 | 0.63 | 0.67 | 0.63 |
| 60-64        | 0.71 | 0.63 | 0.67 | 0.63 |
| 65-69        | 0.71 | 0.65 | 0.68 | 0.65 |
| 70-74        | 0.72 | 0.66 | 0.69 | 0.65 |
| 75 and over  | 0.71 | 0.65 | 0.68 | 0.65 |

| **Middle East and North Africa (18)** |      |      |      |      |
| 15-19        | 0.91 | 0.85 | 0.88 | 0.76 |
| 20-24        | 0.95 | 0.87 | 0.91 | 0.85 |
| 25-29        | 0.95 | 0.87 | 0.91 | 0.89 |
| 30-34        | 0.96 | 0.89 | 0.92 | 0.79 |
| 35-39        | 0.95 | 0.89 | 0.92 | 0.94 |
| 40-44        | 0.96 | 0.90 | 0.93 | 0.95 |
| 45-49        | 0.96 | 0.91 | 0.94 | 0.95 |
| 50-54        | 0.96 | 0.92 | 0.94 | 0.96 |
| 55-59        | 0.96 | 0.92 | 0.94 | 0.95 |
| 60-64        | 0.96 | 0.93 | 0.94 | 0.96 |
| 65-69        | 0.96 | 0.93 | 0.95 | 0.96 |
| 70-74        | 0.96 | 0.93 | 0.94 | 0.97 |
| 75 and over  | 0.96 | 0.93 | 0.95 | 0.96 |

| **South Asia (7)** |      |      |      |      |
| 15-19        | 0.86 | 0.67 | 0.76 | 0.74 |
| 20-24        | 0.91 | 0.72 | 0.81 | 0.82 |
| 25-29        | 0.93 | 0.73 | 0.83 | 0.88 |
| 30-34        | 0.93 | 0.73 | 0.83 | 0.88 |
| 35-39        | 0.95 | 0.76 | 0.85 | 0.93 |
| 40-44        | 0.95 | 0.76 | 0.85 | 0.93 |
| 45-49        | 0.95 | 0.76 | 0.85 | 0.93 |
| 50-54        | 0.96 | 0.80 | 0.88 | 0.93 |
| 55-59        | 0.96 | 0.80 | 0.88 | 0.93 |
| 60-64        | 0.96 | 0.80 | 0.88 | 0.93 |
| 65-69        | 0.96 | 0.78 | 0.88 | 0.93 |
| 70-74        | 0.96 | 0.79 | 0.88 | 0.93 |
| 75 and over  | 0.96 | 0.79 | 0.88 | 0.93 |
Sub-Saharan Africa (33)

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<th>2010</th>
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</table>

Source: Author’s calculations based on Barro-Lee Data (2010)

\[
Gini_{i,t,c} = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} |y_{i,j}^{a}-y_{i,j}^{c}|}{2 \sum_{i=1}^{n} \sum_{j=1}^{n} y_{i,j}^{a} y_{i,j}^{c}}
\]

With

- **a**: Age group; **c**: Country; **t**: Time. Age group "a" corresponds for a=1 to 15–19 age group, a=2 to 20–24 age group, a=13 to 75 and above. \(n\) is the number of levels of education which is equal in our study to 7 levels. \(i\) and \(j\) are educational levels. \(j = 1\) for no formal education, \(j = 2\) for incomplete primary, \(j = 3\) for complete primary, \(j = 4\) for incomplete secondary, \(j = 5\) for complete secondary, \(j = 6\) for incomplete tertiary, \(j = 7\) for complete tertiary. \(n_{i,t,c}\) represents the size of the population at the time "t", in the age group "a" and for the country "c" having attained the educational level "i". \(y_{i,t}^{a}\) is the number of years of schooling accumulated by group "a" to attain the educational level "i" at time "t".

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Figure 3. Education Lorenz Curve by Age Group and Development Level from 1950 to 2010

The evolution over time of the Education Lorenz Curve of the same age group
The evolution over time of Education Lorenz Curve of the same cohort
A cross-section Education Lorenz Curve over age group
Figure 4. Relationship between Education Gini and Average Years of Schooling by Region

Figure 5. Relationship between Standard Deviation of Schooling and Average Years of Schooling (Education Kuznets Curve by Region)

Standard Deviation of Schooling = $SDS = \sqrt{\sum_{i=1}^{n} p_i (Y_i - \mu)^2}$
References


